losa, Eriophorum Virginicum, Fimbristylis spadicea, Rhynchospora inexpansa, R. alba, R. oligantha, R. microcarpa, R. pallida, R. gracilenta, R. Torreyana and R. glomerata. R. corniculata is rather scarce, but increases southward. Dichromena leucocephala, D. latifolia, Scleria triglomerata, S. oligantha, S. Elliottii, S. gracilis and S. laxa abound. Of carices the most common are C. flavescens, C. vulpinoidea and C. lupulina. This genus is by no means so well represented as one would expect.

But the flora of these lonely swamps is, like the swamps themselves, rather monotonous. The collector will often get as complete a set of species in a single day as he can secure by a whole week's labor, even though he force his way, as the writer did,

> "Through tangled juniper, beds of reeds,
> Through many a fen where the serpent feeds,
> And man never trod before."

There are very few grasses to be met with in the swamps, and these are of little interest. Panicum Crus-Galli, Agrostis vulgaris, Panicum dichotomum and Paspalum Floridanum are about all.

The shrubs and trees which sometimes cover the high ridges include Gordonia Lasianthus, Stuartia Virginica, Magnolia glauca, Cyrilla racemiflora, Oxydendron arboreum, Quercus aquatica, Q. Castanea, Alnus serrulata, Cupressus thyoides, Juniperus Virginiana, Acer rubrum, and one or two species of willow.

The Autumnal changes in Maple Leaves.

W. K. MARTIN AND S. B. THOMAS.

The results we would record in this paper were obtained from investigations conducted in the botanical laboratory of Wabash College. The work was done during the time of the autumnal changes, so that abundant and fresh material was constantly at hand. The object was chiefly to note the changes in the cell contents as the death of the leaf approached, and to localize, so far as possible, the changes in color.

The structure of the normal green maple leaf is shown in figure 1, consisting of the ordinary epidermal layer above and below, a single cell in depth, a single layer of rather elongated palisade cells, and usually about three layers of spongy parenchyma, more closely packed than usual. The chlorophyll bodies are small and thickly and evenly distributed throughout the mesophyll cells.

The first indication of the approach of autumnal changes is the withdrawal of the contents of the mesophyll cells. This goes on gradually, but the cells are seldom emptied. The amount of protoplasmic cell contents lost to a plant by the fall of its leaves must be very considerable. The whole mass of the chlorophyll bodies in any cell is much reduced by this process of withdrawal (see figures 2 and 3). At the same time the protoplasm of the cell seems to dispose of much of

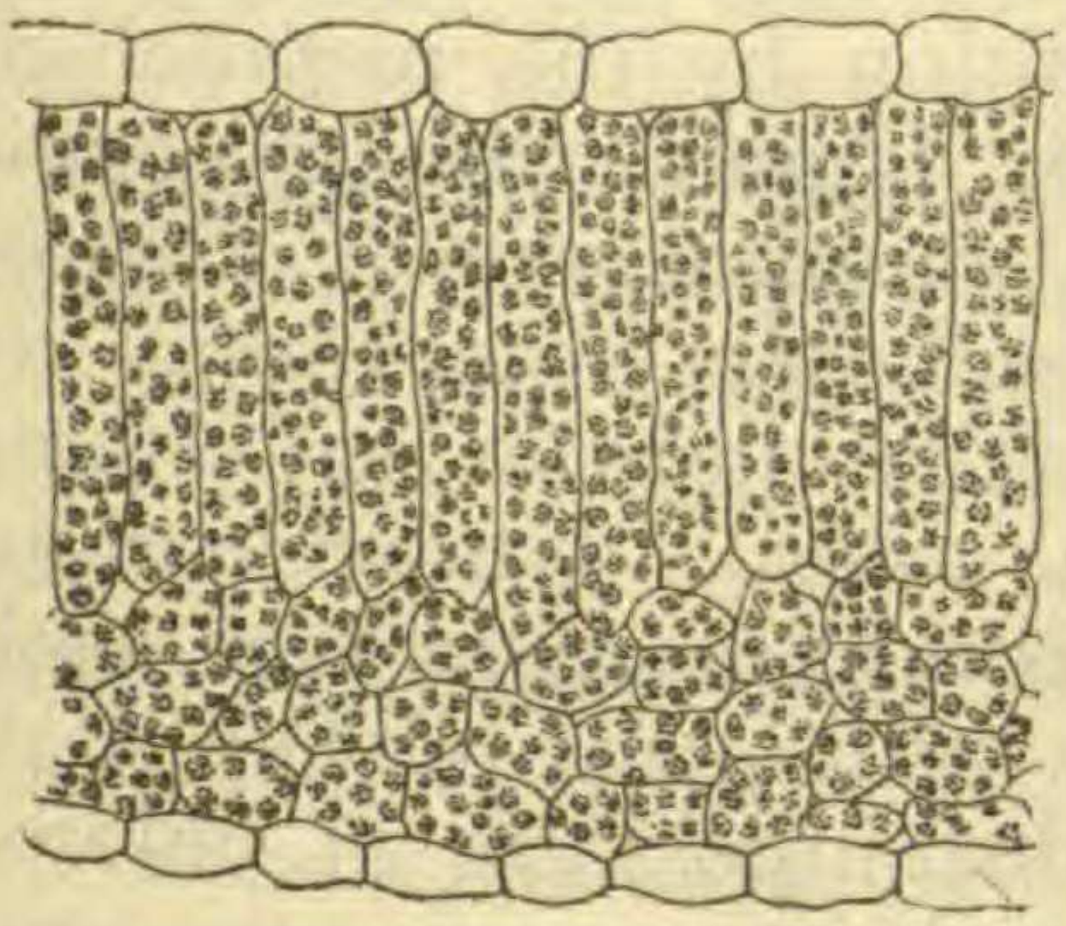

FIG. 1.

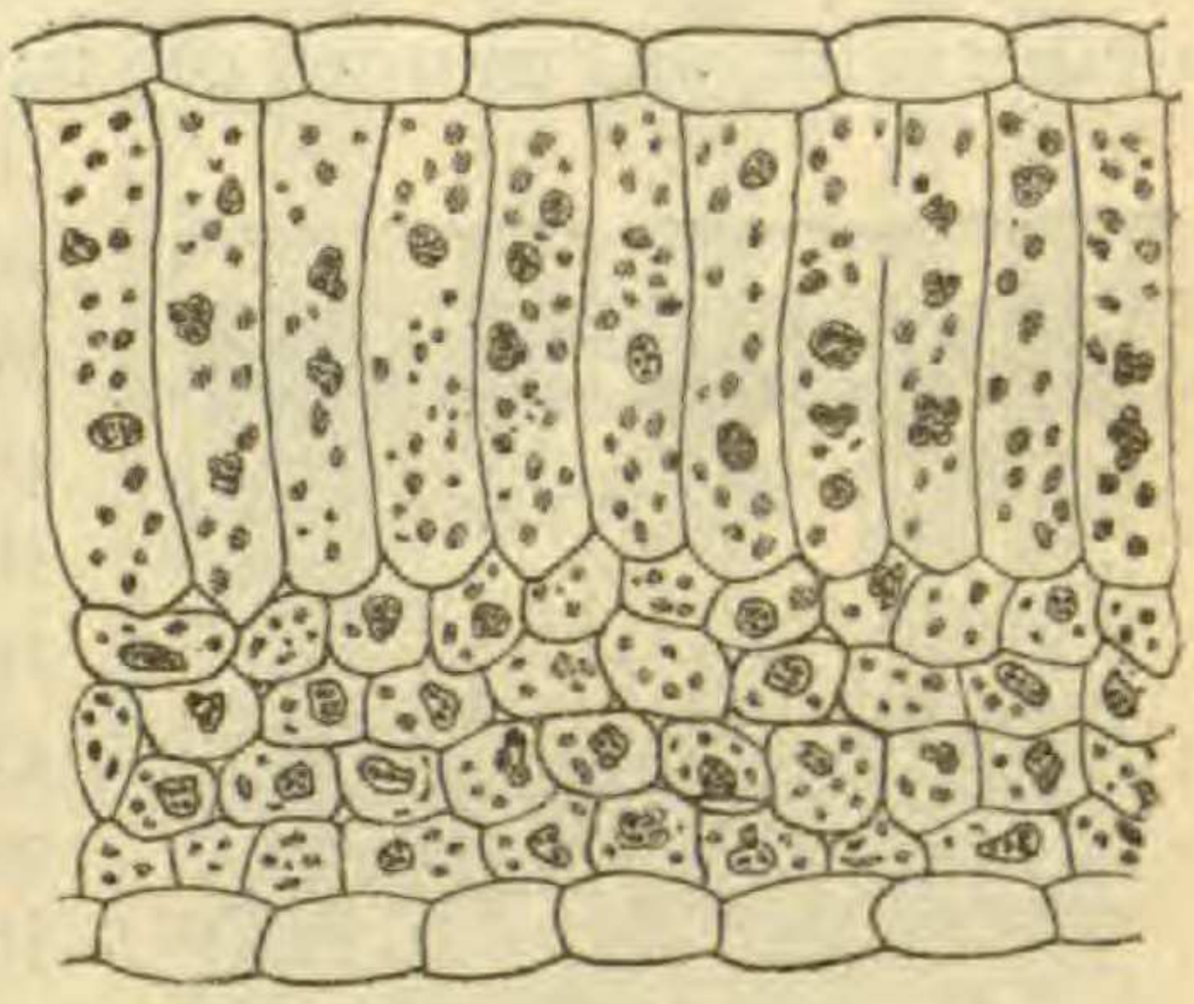

FIG. 2.

its substance in the manufacture of cellulose, chiefly in the palisade cells, in which it is deposited upon the cell walls in successive layers, either uniformly or in restricted patches, or is used occasionally in building a transverse partition across a palisade cell (fig. 4). In every case the lines of stratification are beautifully marked. That this deposit is cellulose was determined by the ordinary tests for that substance. During these changes the chlorophyll bodies are seen both to disintegrate and to blend together in larger masses. In the case of the red leaf these larger masses often become invested by a pellicle which appears to be cellulose.

In the leaf which has become brown (fig. 2), a greater amount of cell contents remain than in the red, the chlorophyll bodies do not mass together so much, and the cell sap is a dirty brown.

In the red leaf (fig. 3) the cell contents are even more reduced, some cells being almost empty, the remaining contents are mostly collected in masses of considerable size and often surrounded by the pellicle referred to, and the cell sap is colored by the characteristic red coloring matter, erythrophyll.

In the yellow leaf the cell contents are much like those of the red leaf, but the cell sap is colorless and the chlorophyll masses are stained yellow by xanthophyll.

What has been said of red and yellow and brown leaves is applicable as well to groups of cells in the case of mottled leaves.

The existence of erythrophyll and xanthophyll in these positions, the former in the cell sap, the latter in the solid cell contents, is of course well known in a general way. But we wish to add an additional fact or two in the explanation of these phenomena. Chlorophyll, manufactured constantly under the influence of light, is as constantly undergoing decomposition by the metabolism of the cell. Under ordinary conditions the manufacture of chlorophyll is sufficient to cover up its decomposition and the leaf retains its green color. Under certain changed conditions, however, such as intense light or diminished vitality, the decomposition of chlorophyll exceeds its manufacture, and xanthophyll (probably one of the products of its decomposition[1]) appears. In other words, xanthophyll is being formed all the time, but only becomes apparent when the manufacture of chlorophyll is checked. The condition of intense sunlight gives us the occasional summer yellowness, while to lowered vitality must be attributed the failure of chlorophyll manufacture in the autumn. This lower vitality is brought about by diminution of light, lowering of temperature, and probably causes in the plant itself. The common notion that frost is the cause of autumnal coloration is true only so far as it is one of the causes which tends to diminish the vitality of the plant and so the manufacture of chlorophyll. Autumnal coloration may take place before any frost. Xanthophyll then stains the chlorophyll masses yellow, which were before stained green by chlorophyll.

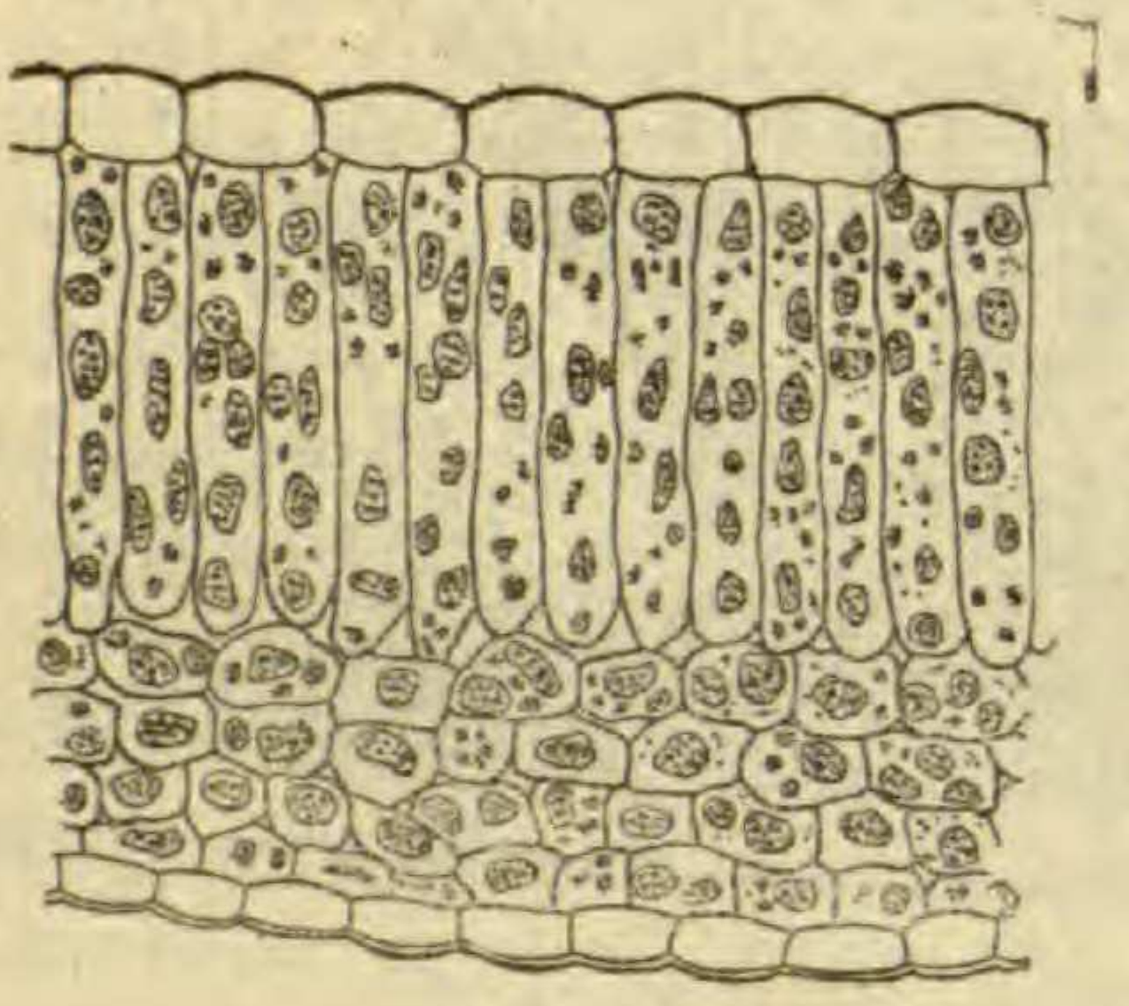

FIG. 3.

The red coloration is brought about in a very different way, as erythrophyll is manufactured in the leaf and stains

[1] Vines' Physiology of Plants, p. 241.

the cell sap, leaving the chlorophyll masses untouched. This red coloring matter can not be discovered in any of the crude materials brought into the plant, or in any other part than the leaves, except sometimes in the phloem regions of the petioles. When the leaf falls and the cell sap evaporates, and the chlorophyll bodies die, the erythrophyll lays hold of the cell wall and solid contents and stains them. In this way dried leaves retain their red color As erythrophyll is soluble in water, however, contact with moisture will soon cause the most of it to disappear. In the case of many cells containing erythrophyll we found the chlorophyll masses retaining their green color. In fact, the green was so slow in disappearing that it was only in the most advanced stages that it had given place to the yellow of xanthophyll. In some cases, where chlorophyll masses were in contact with external cell walls, they had become yellow, while in the same cell those masses completely surrounded with erythrophyll remained green. The explanation of this seems to lie in the fact that in the red rays the decomposition of chlorophyll goes on less actively than in the rays of low refrangibility.[2] The erythrophyll thus acts as a check upon the decomposition of chlorophyll, and so on the appearance of xanthophyll. It thus seems that all the leaves would become yellow but for the presence of erythrophyll. The brown coloration seems to be a modification of the red, the erythrophyll color of the cell sap being replaced by a dirty brown. Whether this is a resultant from the action of erythrophyll upon certain cell contents, or an entirely different coloring matter, was not ascertained.

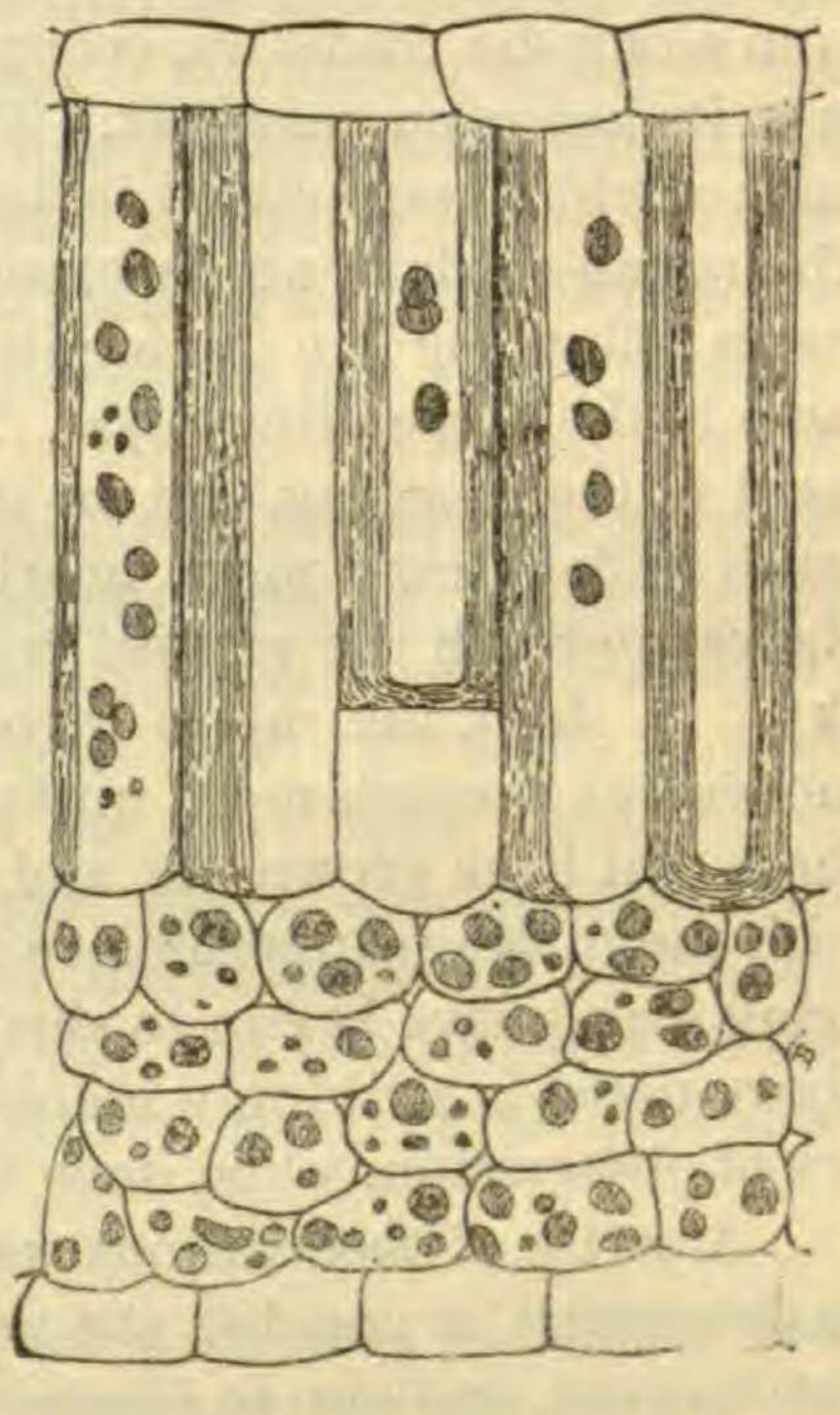

FIG. 4.

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[2]Vines' Physiology of Plants, p. 266.